

## Amendments in the specification

1) Please replace the paragraph beginning on line 18 of page 23 with the following paragraph:

The nominal optical path length difference  $\Delta$   $[[\delta]]$ , measured when there is no micromirror displacement, is in this example the same for all adjacent emergent beams.  $\Delta$   $[[\delta]]$  is a



constant, once the incident angle  $\theta$  and separation length  $T$  are determined. The corresponding phase difference is  $\delta = \frac{2\pi}{\lambda} \Delta$ .

By taking the phase of the first emerging beam as a reference, the relative phase of  $n$ th beam is  $(n-1)\delta$  or,

equivalently,  $\sum_2^n \frac{2\pi}{\lambda} \Delta$  when there is no mirror movement

(summation starting at 2 implies that the light beam reflects from the reflector **26** before the first micromirror). If we move the micromirrors, an additional phase will be added to (or subtracted from) ~~to~~ this free space propagation phase.

2) Please replace the paragraph beginning on line 16 of page 4 with the following paragraph:

Fig. **18** shows an alternative embodiment where the micromirrors have a ~~convex~~ concave shape for collimating the light beam. Fig. **19** shows an optical interleaver according to the present invention.

3) Please replace the paragraph beginning on line 4 of page 6 with the following paragraph:

**Fig. 1** shows a side view of an exemplary embodiment of the present invention. Micromirrors **20** (individual micromirrors are labeled **20a**, **20b**, **20c**...) are disposed on a substrate **22** in a linear array. Each micromirror **20** can be independently moved in a vertical direction **24**. The micromirrors have a period spacing **A**. A floating reflector **26** is disposed above the micromirrors **20** by a spacing ~~a spacing~~ distance **T**. The spacing **T** can be used to describe the positions of individual micromirrors **20**, since they are movable. The floating reflector **26** is partially reflecting and partially transmitting and is held above the micromirror on posts (not shown) or other supporting structure. A lens **28** is disposed above the floating reflector to capture emergent beams **36** transmitted by the reflector **26**. The lens **28** has a focal plane **30** where light patterns are created by the lens **28**.

4) Please replace the paragraph beginning on line 16 of page 11 with the following paragraph:

In the present invention, wavelengths are distributed in the focal plane so that there is a well-defined correspondence between wavelength and position in the focal plane. **Fig. 2**, for example, shows a plot of wavelength versus focal plane position (in the instance where all micromirrors have the same value of **T**). Wavelength varies approximately linearly with linear position in the focal plane. A larger view of the wavelength vs. focal plane position in **Fig. 3** reveals that the wavelength pattern repeats in the focal plane. Each repeating unit is called a 'window' in the present description (typically, a window can be about 0.5-3mm wide, for example).<sub>[[ ]]</sub> The wavelength range in each repeating

'window' is equal to the FSR of the device. Each window corresponds to a different diffraction order. Typically (and desirably), most of the optical energy is located in a single window, but the invention is not so limited. In the example of ~~Figs~~ Figs. 2 and 3, the FSR is equal to the wavelength range  $\lambda_1$ - $\lambda_7$ , or 7 nm.

5) Please replace the paragraph beginning on line 2 of page 13 with the following paragraph:

It is important to note that mirror **42** moves a very small amount to cause the wavelengths to shift. The required vertical displacement is a small fraction of the wavelength used (e.g.  $1/10\lambda$  to  $1/2\lambda$  for example). 1530-1580nm may be a typical wavelength range used, and T may be about 50-400 microns, so T is not significantly changed by mirror displacements required for wavelength shifting. Therefore, the FSR is not significantly changed as wavelengths are shifted between optical fibers **40**.

6) Please replace the paragraph beginning on line 31 of page 14 with the following paragraph:

In the present invention, the reflector **26** can have a uniform reflectivity or graded (nonuniform) reflectivity. The reflectivity of the reflector strongly influences the amplitude of the emergent beams **36**, which affects ~~effects~~ the device resolution.

7) Please replace the paragraph beginning on line 25 of page 15 with the following paragraph:

**Fig. 14** shows a plot of beam energy versus beam number for a device with an energy distribution varying according to a sinc function  $(\text{sinc}(x) = \sin(x)/x)$   ~~$(\sin x/x)$~~ . A sinc function energy distribution tends to focus each wavelength to a box-like area since the Fourier transform of a box is a sinc distribution. Focusing each wavelength to a box-like area tends to provide lower crosstalk between adjacent channels. A sinc function beam energy distribution can be provided by appropriately grading the reflector reflectivity, or by other techniques discussed below.

8) Please replace the paragraph beginning on line 17 of page 16 with the following paragraph:

**Fig. 15** shows a perspective view of an alternative embodiment of the present invention where each micromirror is capable of independently modulating its reflectivity. This allows independent control of the amplitude of each emergent beam 36. In the device of **Fig. 15**, each micromirror 20a, 20b, 20c, 20d comprises separately movable mirror diffractive elements 43 (typically at least 4 elements per micromirror). Reflector 26 is a narrow strip aligned over the micromirrors 20. The lens 28 and focal plane are not shown in **Fig. 15**. The separately movable mirror elements 43 act as a diffraction grating when they are positioned at different heights. In operation, light beam 32 reflects between the reflector 26 and micromirrors 20 when the mirror elements 43 are coplanar. When elements 43 are positioned at different heights (e.g. like micromirror 20b), light beam 32 is partially diffracted.

The diffracted light misses the reflector **26** and becomes the emergent beam **36**, which is collected by lens **28** (not shown). The undiffracted portion of light beam **32** continues to reflect between the reflector **26** and micromirrors **20**. By adjusting the positions of the elements **43**, the amount of energy in the emergent beam **36** can be controlled. Specifically, the less coplanar the elements **43**, the more energy is present in the corresponding emergent beam **36**. If all the micromirrors in the device comprise elements **43**, the energy of each emergent beam **36** in the present invention can be independently controlled. For more information on controllable diffraction gratings, and movable mirror elements, reference can ~~be made~~ be made to US patents 5,459,610 and 5,808,797 to Bloom et al.

9) Please replace the paragraph beginning on line 12 of page 17 with the following paragraph:

It is noted that the diffractive elements **43** can move in unison so that the elements **43** act as a single micromirror. ~~micromirror~~. In this way, the elements **43** can provide phase tunability without affecting the energy of the emergent beams **36**. So, when a micromirror comprises diffractive elements **43**, the diffractive elements can be actuated to provide independent control over energy and phase of the corresponding emergent beam **36**.

10) Please replace the paragraph beginning on line 21 of page 17 with the following paragraph:

**Fig. 16** shows a closeup perspective view of a single micromirror **20** comprising diffractive elements **43**. ~~Reflector~~ Reflector 26 is shown as a layer of material with a highly reflective region **26a** and a highly transmissive region **26b**. The reflective region **26a** is disposed to reflect undiffracted light beam **32**; the transmissive region is disposed to transmit diffracted light that forms emergent beam **36**. The device of **Fig. 16** is not shown to scale; typically, the reflective region **26a** will be as wide or wider than the micromirror **20**.

11) Please replace the paragraph beginning on line 17 of page 18 with the following paragraph:

**Fig. 18** shows an alternative embodiment where the micromirrors **20** have a ~~convex~~ concave shape focusing the light beam **32**. Although every micromirror **20** is shown having a ~~convex~~ concave shape, it is also possible to make a device with both flat and ~~convex~~ concave micromirrors. For example, every second or third micromirror **20** can have a ~~convex~~ concave shape, and other micromirrors can be flat. In operation, the ~~convex~~ concave shape of the micromirrors **20** causes the light beam **32** to be repeatedly refocused. Alternatively, the reflector **26** can have ~~convex~~ concave bumps indentations for refocusing the light beam **32**. It is noted that the mirror **42** of **Fig. 4** can have an array of ~~convex~~ concave shapes for focusing the light beam **32**.

12) Please replace the paragraph beginning on line 9 of page 22 with the following paragraph:

According to the present invention, the shape of the spatial energy distribution (e.g. solid line 60 in Fig. 24) is a function of the vertical positions of the micromirrors 20. A ~~Technique~~ technique for calculating micromirror positions from desired energy distribution shapes is described below in the 'Theory and Algorithms' section. The filter of the present invention is reconfigurable because the shape of the energy distribution 60, and hence the passband widths, is adjustable. Also, FSR is adjustable by changing T.

13) Please replace the paragraph beginning on line 17 of page 24 with the following paragraph:

The important thing to remember here is that all emergent beams are tapped from a single light beam 32, and the effect of micromirror repositioning ~~reposition~~ propagates to all the emergent beams downstream. In other words, the phase term of

~~nth beam is should be~~ equal to  $\sum_{k=2}^n (\delta + \phi(k))$ . From this

expression, it follows that the phasor representation of nth beam can be written as  $E_n e^{j\psi(n)} e^{j\delta(n-1)}$ , where  $\psi(n)$  is the effective phase shift of the nth beam accumulated from the phase shifts from upstream micromirror reflections. That is,

$$\psi(n) = \sum_{k=2}^n \phi(k).$$

14) Please replace the paragraph beginning on line 18 of page 25 with the following paragraph:

Assuming the device can be modeled as a multiple-slit system, ~~and within the~~ Fraunhofer approximation, the electric field

(far field) E measured at angle  $\sigma$  and distance R after focusing (or transforming) lens can be written as:

$$\cancel{E(R, \sigma, t) = \text{Im} \left[ (bCe^{j(\omega t - kR)}) \left( \frac{\sin \beta}{\beta} \right) \left( \sum_{n=0}^{N-1} E_{n+1} e^{j\psi(n+1)} e^{jan} \right) \right]} \quad \text{Eq. } \cancel{1}$$

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$$E(R, \sigma, t) = \text{Im} \left[ (bCe^{j(\omega t - kR)}) \left( \frac{\sin \beta}{\beta} \right) \left( \sum_{n=0}^{N-1} E_{n+1} e^{j\psi(n+1)} e^{jan} \right) \right] \quad \text{Eq. } 1$$


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where:

$\alpha = \delta + 0.5k a \sin \sigma_L$   $\beta = 0.5k b \sin \sigma_L$   $k = \frac{2\pi}{\lambda}$ ,  $\omega$  is angular velocity,  $t$  is time, and  $C$  is a constant.

15) Please replace the paragraph beginning on line 1 of page 29 with the following paragraph:

**Case (1): Adjustment of amplitude and phase**

In this case, the problem is well analyzed in digital signal processing literature. Specifically, the problem is solved in connection with transversal filter filters. For more information, reference can be made to "Discrete-Time Signal Processing" by Oppenheim et al. In the present invention, phase is adjusted by vertical positioning of the micromirrors, and amplitude can be adjusted by reconfigurable diffraction gratings (as described with reference to **Figs. 15-16**), or spatial light modulators.

16) Please replace the paragraph beginning on line 11 of page 29 with the following paragraph:

**Case (2): Adjustment of phase only**

In this case, only the phases ~~is~~ are adjusted, and the problem can be restated as:

Find  $(u_1, u_2, u_3, \dots, u_N)$  for  $B_1(x) < |F\{U\}| < B_u(x)$ , where  $|u_1|, |u_2|, |u_3|, \dots, |u_N|$  are given.

17) Please replace the paragraph beginning on line 24 of page 29 with the following paragraph:

It is noted that, if certain bounds  $B_u, B_1$  require micromirrors to be ~~nonplanar~~ non-coplanar (i.e. micromirrors have different heights and associated values of  $T$ ), then wavelength cycling is provided by moving all the micromirrors the same amount, so that relative vertical positions of the micromirrors remain constant.